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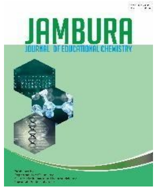

Development of Learning Videos on the Atomic Model Concepts Based on Multilevel Representation

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Abstract

This study was motivated by difficulties in learning complex and abstract concepts in atomic model development, while commonly used learning videos still provide limited representation, reducing students' ability to connect concepts with real phenomena. This study aims to develop a multilevel representation-based learning video on atomic model development and to examine its validity, practicality, and effectiveness using a research and development approach involving planning, production, and evaluation stages. The subjects in this study included 2 media experts, 2 material experts, 1 chemistry teacher, and 60 tenth-grade students from classes X-5 and X-6 at SMAN 14 Samarinda. Product validity was assessed by experts, practicality was measured through teacher and student questionnaires and activity observations, and effectiveness was analyzed by comparing pretest and posttest results quantitatively. The results show very high validity, with material expert validation reaching 100% and an average media expert score of 99.25%. Teacher practicality was categorized as very practical, with questionnaire and observation scores of 96.67% and 98.33%, while student practicality scores reached 82% and 81.7%, categorized as practical. The effectiveness of the media was demonstrated by an N-gain value of 0.56 (moderate) and an effect size of 4.94 (very strong), supported by positive student responses with ease of understanding scoring of 82.17% and learning interest of 86.33% (excellent category), while learning activity (79.66%) and media practicality and features (79.83%) fell into the good category. These findings confirm that multilevel representation-based learning videos effectively enhance students' understanding of atomic model development.

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1. INTRODUCTION

Chemistry education in high school covers various concepts that are complex, abstract, theoretical, and often require memorization. One topic that falls into this category is the development of atomic theory, starting from the Dalton, Thomson, Rutherford, Bohr, and Quantum Mechanics models. The complexity of this material often causes difficulties for students in understanding basic chemistry concepts (Wijaya, 2020). Abstract chemistry materials often require higher-order thinking skills and can become an obstacle for students in mastering concepts in depth (Mulyanti et al., 2023). Therefore, effective learning strategies and media are necessary in order to help the students understand and master abstract concepts more effectively.

To help students understand difficult chemistry concepts, learning should combine three types of representations: macroscopic, sub-microscopic, and symbolic. The relationship between the three kinds of representations is very important because understanding chemistry requires students' ability to connect and move between representations consistently, for example, connecting events in an experiment (macroscopic) with images of particles or electrons (submicroscopic) and images or symbols of atomic models (symbolic) (Adawiyah et al., 2021). Recent research shows that

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when learning explicitly connects these three levels through the development of relationships between representations and the use of interactive media, students' conceptual understanding increases significantly (Kapici, 2023; Sanchez, 2025)

Video-based learning media is an effective alternative for teaching abstract chemistry concepts. Video has the advantage of delivering content in an audio-visual format, making the presentation of material more engaging and boosting student motivation and learning outcomes (Dewi & Putrawansyah, 2021; Putri et al., 2022). Several studies show that the use of chemistry learning videos not only improves students' understanding but also their activity and involvement in the learning process, such as in the materials on electrolyte solutions, solubility, and colloid properties (Banu et al., 2022; Tukan et al., 2022; Widarti et al., 2020) Therefore, video media can be a practical and effective tool in facilitating complex chemistry learning.

However, learning videos commonly used in chemistry instruction still exhibit several limitations, as they often present atomic models descriptively without explicitly linking macroscopic phenomena, submicroscopic particle behavior, and symbolic representations, leading students to focus on memorization rather than conceptual understanding. Previous research by Nurfitriana et al. (2022) showed that animated videos on atomic model development mainly emphasize submicroscopic and symbolic levels with limited macroscopic representation and use monotonous narration, which may reduce student engagement. Similarly, Santoso et al. (2023) reported that animated videos on atomic structure developed using PowToon primarily focus on theoretical explanations and symbolic representations, while providing limited visualization of particle interactions connected to observable phenomena. These findings indicate a clear gap in existing learning media, particularly the need for multilevel representation-based videos that systematically integrate macroscopic, submicroscopic, and symbolic levels to support meaningfully conceptions of atomic models.

To overcome students' difficulties in understanding the development of atomic models, the aim of this study is to develop practical and effective multilevel representational learning videos that integrate macroscopic phenomena, sub-microscopic particle interactions, and symbolic representations, as well as to evaluate their validity, practicality, and effectiveness. The novelty of these studies lay in the explicit incorporation of multilevel representations in an instructional video on atomic model development, which had not been sufficiently addressed in previous instructional videos. Research by Sundari et al. (2021) has shown that video-based learning supported by student worksheets (LKPD) improves learning outcomes in abstract chemistry topics, while research by (Akay et al., 2022) indicates that multilevel representation-based videos are practical for teachers and effective in promoting active student engagement. In the future, this research is intended to support the development of multilevel representational digital educational media for other abstract chemistry topics and assist teachers in designing conceptually meaningful instruction connected to representations.

2. METHOD

2.1. Type of Research

This research was carried out using the Research and Development (R&D) method with the PPE (Planning, Production, Evaluation) model from Richey & Klein (2009). In the planning stage, students' needs were analyzed, and material characteristics were studied to design appropriate learning media. The production stage included the process of media creation, content compilation, and product validation by material and media experts to obtain results regarding the practicality of using chosen media. Next, the evaluation stage was carried out through limited trials in the classroom to assess the effectiveness of the product, with data obtained from student response questionnaires and improvements in conceptual understanding based on learning outcomes.

2.2. Subjects and Objects of Research

The subjects in this study involved several parties participating in the development and limited implementation of the learning video, namely 2 media experts, 2 material experts, 1 chemistry teacher, and tenth-grade students at SMAN 14 Samarinda. The student sample consisted of two intact classes, X-5 and X-6, selected using purposive sampling. The selection criteria included tenth-grade classes as the target population, classes that were learning or scheduled to learn atomic model concepts in accordance with the curriculum, and classes demonstrating adequate readiness for digital media–assisted learning. The total

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number of students involved was 60, with 30 students in each class. The learning video intervention was implemented in a single session lasting 80 minutes. This study did not use a control group and design to develop and assess the practicality and effectiveness of the developed multilevel representation-based atomic model learning video. The object of this study was a learning video concerning the development of a multilevel representation-based atomic model.

2.3. Data Types and Sources

This study used two types of data, which are quantitative and qualitative data. The quantitative data were collected through pre-test and post-test results, while qualitative data were obtained based on observation and questionnaires.

2.4. Development Procedure

The development procedure in this study followed the PPE (Planning, Production, Evaluation) model. In the Planning stage, a needs analysis is carried out through documentation, observation, interviews, and questionnaires to identify learning problems in the atomic model development material and determine the appropriate media characteristics. The Production stage included storyboard development, multilevel representation content design, and instructional video production. The developed products were then validated by subject matter experts and media experts using a Likert scale questionnaire covering aspects of content quality, appearance, and usability, accompanied by suggestions for improvement. The Evaluation stage aimed to measure the practicality and effectiveness of the media. Practicality was evaluated by teacher and student by using questionnaires regarding their experiences with the media in the learning process, while effectiveness was measured by comparing pre-tests and post-test results to determine improvements in student understanding. Observations of teacher and student activities are also conducted to supplement the data, using the Guttman scale and Likert scale in accordance with the established indicators.

2.5. Research Instruments

Research instruments in the development of multilevel representational atomic model learning videos include validated validation sheets, validated practicality questionnaires, and validated learning outcome tests. The validity of the media is assessed by subject matter experts and media experts using Likert scale-based validation sheets. Subject matter experts assess the suitability of the material and the accuracy of the concepts, while media experts assess the visual appearance and presentation quality. The validation results are analyzed in the form of percentages to determine the level of media validity. The practicality of the media is measured using a questionnaire for teachers and students after using the video in learning. Practicality data were analyzed based on response percentages to determine the practicality category of the media. The effectiveness of the learning video was analyzed through a pretest and posttest. The increase in learning outcomes was calculated using the N-gain formula to determine the increase in students' conceptual understanding.

2.6. Data Analysis Techniques

The validity of the multilevel representation-based atomic model learning video was obtained from assessments by subject matter experts and media experts using a Likert scale questionnaire. Scores will be counted as percentages and then categorized from low validity to high validity. The media was deemed suitable for use if it obtained a minimum average score in the valid category. Formula 1 was used to calculate the percentage of scores obtained.

$$\text{Validity Percentage} = \frac{\text{Score obtained}}{\text{Maximum score}} \times 100\% \qquad (1)$$

The interpretation of validity levels in this study follows percentage-based classification guidelines, similar to those applied by Lubis et al. (2022), where a range of ≥75% was included in the highly valid category.

Table 1. Validity Level Category

Validity Value (V, %)	Category
$75 < V \leq 100$	Very high validity
$50 < V \leq 75$	High validity
$25 < V \leq 50$	Not enough validity
$0 < V \leq 25$	Low validity

To measure practicality in learning media, the data analysis method generally involves the utilization of practical questionnaires and observation sheets. According to Irsalina & Dwiningsih (2018) and Zakyanto & Wintarti (2022), questionnaire data from teachers and students were processed using Microsoft Excel with a percentage formula, where P is the final score, SRe is the average questionnaire score, and SRh is the maximum questionnaire score. The practicality percentage obtained was then categorized based on Table 2.

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$$p = \frac{SRe}{SRh} \times 100\% \quad (2)$$

Table 2. Practicality category

Percentage (P, %)	Category
85 < P ≤ 100	Very practical
75 < P ≤ 85	Practical
60 < P ≤ 75	Quite practical
50 < P ≤ 60	Not enough practical
0 < P ≤ 50	Not practical

According to Nurramadhani et al. (2025), the student feedback questionnaire was used as a tool to evaluate students' views on the implementation of the learning process, with detailed indicators listed in Table 3.

Table 3. Questionnaire indicators

No.	Indicator
1	Ease of understanding the material
2	Activeness in learning
3	Practicality and media features
4	Student interest

According to Tampubolon in Pertianti et al. (2025), analysis of the observation sheet was carried out by calculating the score using Formula 3 via Microsoft Excel.

$$\text{Percentage of observation sheets} = \frac{\text{Score obtained}}{\text{Maximum Score}} \times 100\% \quad (3)$$

The results are categorized based on Table 4 of teacher and student activities to assess the quality of learning implementation.

Table 4. Teacher and student activity categories

Activity Value (A, %)	Interpretation
80 < A ≤ 100	Very high quality
60 < A ≤ 80	Quality
40 < A ≤ 60	Enough
20 < A ≤ 40	Low quality
0 < A ≤ 20	Very poor quality

Data analysis techniques were applied in these studies to evaluate the effectiveness of an instructional video about atomic models that combined various representations. The analysis process began with a normality test to determine the data distribution pattern as a basis for selecting the appropriate statistical method. A homogeneity test was then applied to ensure the similarity of variance between data groups. The paired t-test was conducted to evaluate whether student skills differed significantly before and after watching the learning video.

To measure the improvement of student learning outcomes after using multilevel representation-based atomic model instructional videos, an analysis was conducted using the N-Gain Test by comparing pre-test and post-test scores based on Formula 4. The N-Gain values obtained were then analyzed with reference to the improvement categories in Table 5. If the results showed a significant improvement, the effect size of one group was calculated using Microsoft Excel and Formula 5. As explained by Olii et al. (2024), the effect size value was interpreted with reference to Cohen's criteria as listed in Table 6.

$$\text{N-Gain} = \frac{\text{Posttest Score-Pretest Score}}{\text{Maximum score-Pretest score}} \times 100\% \quad (4)$$

Table 5. N-gain category

N-Gain Score	Category
G > 0.70	High
0.30 < G ≤ 0.70	Medium
G ≤ 0.30	Low

$$\text{Effect Size (ES)} = \frac{\text{Posttest Average-Pretest Average}}{\text{Pretest standard deviation}} \times 100\% \quad (5)$$

Table 6. Effect size category

Effect Size	Category
ES > 1.10	Very high
0.75 < ES ≤ 1.10	High
0.40 < ES ≤ 0.75	Currently
0.15 < ES ≤ 0.40	Low
ES ≤ 0.15	Very low

The percentage of student responses was analyzed using Microsoft Excel with calculations based on Formula 6. The results of the calculations were then classified into categories compiled by Ardiman et al. (2021), as listed in Table 7.

$$\text{Percentage} (\%) = \frac{\text{Score obtained}}{\text{Maximum score}} \times 100\% \quad (6)$$

Table 7. Response percentage category

Percentage	Category
80 < SR ≤ 100	Very good
70 < SR ≤ 80	Good
60 < SR ≤ 70	Quite good
50 < SR ≤ 60	Less good
SR ≤ 49	Not good

3. RESULT AND DISCUSSION

3.1. Result

This study produced multilevel representation-based instructional videos covering atomic model development. The learning video can be accessed via mobile phone or computer. The development of these learning videos was carried out in three stages:

1. Planning

a. Material analysis

The material analysis has been reviewed in Permendikbud No. 8 of 2022 with Learning Outcomes (CP) for phase E of senior high school, in which the students were expected to observe, investigate, and explain phenomena based on scientific principles in explaining chemistry concepts in daily life. The material on the development of the atomic model is classified as complex, abstract, theoretical, and memorization-based material.

The analysis results show that the material on the development of atomic models is complex and difficult to understand by many students. The selection and use of appropriate learning media will make the process of learning much more interesting and assist students in understanding the material, especially complex and abstract material. Abstract concepts can be understood fully if learning emphasizes multiple representations.

b. Needs analysis

Based on the needs analysis, chemistry teachers delivered material on the development of atomic models through various interesting sources that students showed interest. However, the media used was still limited to two levels of representation, namely sub-microscopic and symbolic, and there was no integration of all three levels of representation. Therefore, teachers and students supported the development of a multilevel representational-based instructional video on the development of atomic models.

2. Production

At this stage, designing and developing instructional videos on multilevel representation atomic model development is tailored according to chemistry teachers and students need for engaging and effective learning media which could be used in learning activities. The learning videos were then incorporated into distribution tools that can be accessed via PCs and smartphones, as shown in Figure 1. The material is explained with visual descriptions from the beginning to the end. After that, it is supplemented with audio consisting of music, narration, sound effects, and direct sound. The instructional video is also equipped with documentaries, features, quizzes, news talk shows, and so on that can increase student motivation to learn, as shown in Figure 2.

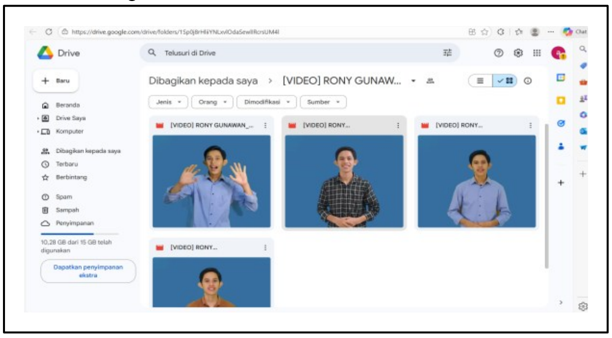

Figure 1. Front view of learning videos in Google Drive

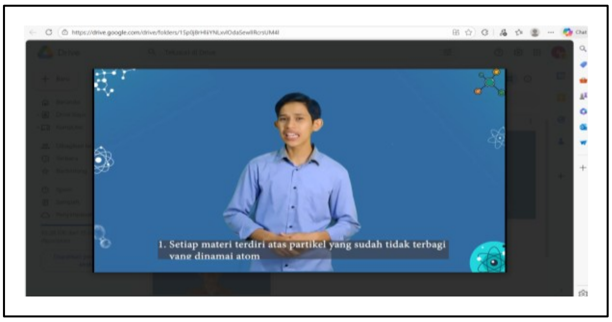

Figure 2. Display of learning video content

3. Evaluation

a. Validation by material and media experts

At this stage, the learning video on the development of the atomic model was validated through subject and media experts to ensure appropriateness in terms of content and quality of presentation. Although the quantitative validation results from the subject matter experts indicated a score of 100% and were categorized as very valid, as shown in Table 8, the validators provided qualitative suggestions for improvement. The revision focused on simplifying the language and correcting several conceptual and theoretical inaccuracies, particularly related to the explanation in the video of Dalton's atomic model of nuclear fusion reactions. An incorrect description suggesting that barium and krypton recombine to form uranium was revised to accurately explain that the fission of a uranium nucleus occurs due to neutron collision, producing barium, krypton, three neutrons, and a large release of energy, with the emitted neutrons inducing a continuous chain reaction. These revisions ensured that the material indicators were fully

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aligned with accepted scientific facts, concepts, and theories.

Table 8. Results of validation by material experts

No	Aspect	Validator 1	Validator 2	Criteria
1	Clarity of message	100%	100%	Very valid
2	Standing alone	100%	100%	Very valid
3	User Friendly	100%	100%	Very valid
4	Content representation	100%	100%	Very valid
5	Visual	100%	100%	Very valid
6	Classical and Individual	100%	100%	Very valid

The learning video media was also validated by media experts. According to the experts, the aspects of user-friendly, audio, and resolution received a score of 100%, while the aspect of visualization received a score of 97% because some video clips did not achieve the optimal resolution of 1080p. Nevertheless, all aspects remain in the very valid category, as shown in Table 9. With a high level of validity, the developed media can proceed to the practicality and effectiveness test stage in order to assess its support for student understanding and learning quality.

Table 9. Results of media expert validation

No	Aspect	Validator 1	Validator 2	Criteria
1	User friendly	100%	100%	Very valid
2	Visualization	97%	100%	Very valid
3	Audio	100%	100%	Very valid
4	Resolution	100%	100%	Very valid

b. Practicality of learning videos

The results of the teacher practicality questionnaire were in line with the category of very practical, with an average score of 96.67%, as shown in Table 10. The final score of the teacher practicality questionnaire on multilevel representation-based learning videos was in the range of 85%-100%, which is classified as very practical according to the practicality category table. The student practicality questionnaire results showed that all practicality indicators fell into the practical category with an average of 82%. Referring to Table 2, the practicality category showed that the students' final practicality questionnaire scores for multilevel representation-based learning videos were in the range of 75–85%, which met the practicality criteria. From these results, it could be concluded students also consider multilevel representation-based instructional videos as a practical learning medium.

Table 10. Results of the teacher and student practicality questionnaire

Practicality questionnaire	Percentage (%)	Category
Teacher	96.67%	Very practical
Student	82%	Practical

The data supporting the practicality survey results are observation sheets taken during teaching and learning activities by students and teachers, as shown in Figure 3. According to the results of observing the activities of students and teachers, teachers' average activity rate was 98.33%, and students' average activity rate was 81.17%, which was categorized as excellent. The interaction between students and teachers during the learning activities is very important to measure their engagement level. Students who feel emotionally and instructionally supported by teachers tend to be more active in asking questions, responding, and discussing with both teachers and peers. This shows the importance of dynamic interactions that encourage students' curiosity, which in turn deepens their understanding of the material being studied, including chemistry (Zeinstra et al., 2023).

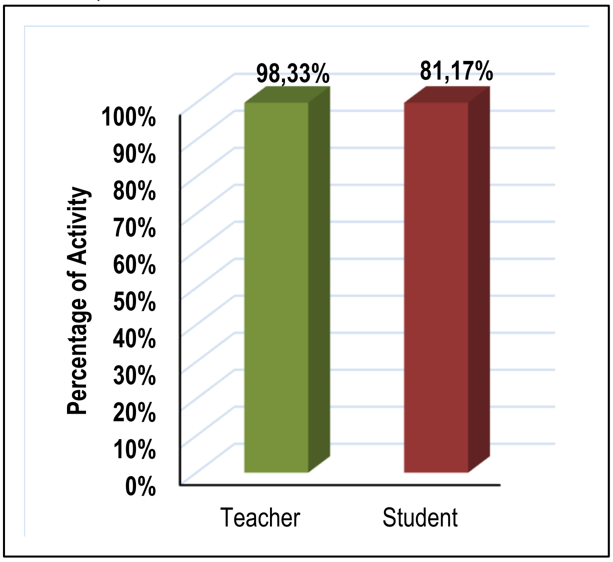

Figure 3. Teacher and the student activities

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c. Effectiveness of learning videos

Students' comprehension skills were evaluated according to the results of pre-tests and post-tests. To evaluate the effectiveness of these instructional videos in improving students' comprehension skills, an N-Gain test was performed. Prior to the N-Gain test, a prerequisite test was conducted, beginning with a test of normality to determine whether the pre-test and post-test mean scores were normal using the Shapiro-Wilk test in SPSS. The results showed a significant increase in improving students' comprehension after using multilevel representation-based learning videos. The increase was measured by an N-Gain score of 0.56, which falls into the moderate category. In addition, an effect size analysis was conducted, which resulted in a score of 4.94, which is in the category of very high. This shows that the usage of multilevel representation-based instructional videos had a significant impact to improve students' comprehension skills.

As supporting evidence for the effectiveness of this study, the student response questionnaire results regarding learning using instructional videos for atomic model development material are presented in Figure 4.

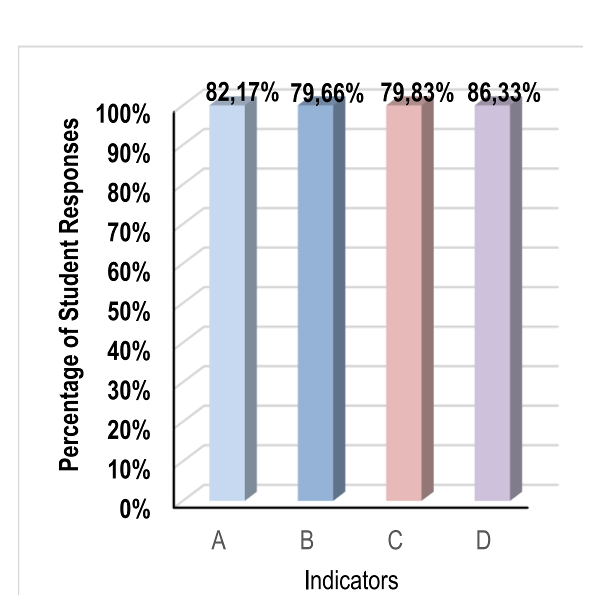

Figure 4. Student responses

Based on Figure 4, the result of the student response questionnaire concerning learning using multilevel representation-based learning videos shows that the measured indicators are in the excellent category. The average ease of understanding the material obtained an average score of 82.17%, and student interests obtained an average score of 86.33%, which are included in the excellent category. However, two indicators were low, namely activity in learning, which obtained an average score of 79.66%, while practicality and media features obtained an average score of 79.83%, which are included in the good category.

3.2. Discussion

The development of multilevel representation-based educational videos on the topic of atomic model development aims to improve students' understanding of complex concepts. The use of educational videos in chemistry helps students understand complex concepts by presenting clear and easy-to-understand visual images. Videos created with a multilevel representation approach, which combines visual, symbolic, and audio elements, provide a solution in facilitating students' understanding of the concept of the development of the atomic model (Fitriani et al., 2023; Paristiowati et al., 2024). The effectiveness of this approach can be explained through multilevel representation theory, which states that students achieve deeper conceptual understanding when concepts are presented through interconnected representational levels rather than a single form of representation. This principle is strongly aligned with Johnstone's Chemistry Triangle, which emphasizes that chemistry understanding is achieved through the balanced integration of macroscopic, sub-microscopic, and symbolic levels of representation (Spitha et al., 2023).

In the planning stage, material analysis is conducted to analyze learning outcomes for atomic model development material based on Permendikbud No. 08 of 2022, which is included in phase E of grade X. This aims to identify various problems in the learning process before designing interventions and learning media. According to Junaidin (2022), problem identification allows researchers to reveal the "gap" between actual conditions and expectations in learning before formulating the needs and objectives of media development. At this stage, a preliminary analysis was conducted by observing and interviewing chemistry teachers. The analysis results show that the material on the development of atomic models is complex and abstract, which makes chemistry difficult for students to understand. According to Erlina et al. (2023), the material on the development of atomic models will be easier to understand as a whole to achieve learning objectives if the learning emphasizes multi-level representation. According to Johnstone, difficulties in chemistry learning often arise when instruction emphasizes only one representational level, causing students to fail in connecting observable phenomena with particle-level explanations and symbolic models (Nkomo & Bly, 2024).

The shortcoming of the learning videos currently in circulation is that they only focus on delivering information in sub-microscopic, symbolic, and narrative forms, which can cause difficulties for students in understanding chemistry material as a whole. This often leads to misconceptions and superficial understanding, as students find it difficult to relate these representations to real phenomena that can be observed in daily life. (Komara et al., 2024). From the perspective of Johnstone's Chemistry Triangle, this imbalance prevents students from forming a complete conceptual framework, as the macroscopic level serves as the entry point for meaningful learning (Petillion & McNeil, 2020). At this stage, an analysis of the needs of students and teachers regarding the subject matter to be delivered and the design of multilevel representation-based learning media was also carried out for the development of the atomic model.

During the production stage, instructional videos were designed to facilitate the production of valid and usable videos after assessment by media and material experts, with excellent results (Ramadana, 2023). At this stage, the instructional video media design was developed to present multi-level representations. Experimental videos and real examples were used to illustrate the macroscopic level of the atomic model development material. Meanwhile, the sub-microscopic level, which can't be seen with the naked eye, is described through animations that show the movement of particles. For the symbolic level, the atomic model was displayed in the form of images to clarify the material on the development of atomic models. The integration of these three levels supports cognitive linking processes, enabling students to move between observable phenomena, particle behavior, and symbolic models coherently.

Media experts conducted validation to assess user-friendliness, visualization, audio, and resolution. In several aspects, such as user-friendliness, the video on atomic model development was classified as excellent, indicating that the educational video used was clear and easy to understand. After making improvements to several aspects based on the suggestions provided by media experts, the video received a score of 99.25% and was classified as highly valid. Material expert validation was conducted to assess the aspects of message clarity, user-friendliness, content representation, visualization, classical, and individual aspects. The validator suggested consistency in presenting the weaknesses of the atomic model in the learning video at the beginning of the video. After considering the advice and input from the subject-matter expert validators, the video achieved a 100% validity score and was categorized as very highly valid.

The purpose of using multilevel representation-based learning videos is to measure the extent to which students can understand the material on atomic model development after using this media. At this stage, data on the use of multilevel representation-based learning videos will be collected to assess the extent to which this media is effective and practical in improving student understanding. According to the practicality questionnaire completed by teachers and students, the average score for teachers was 96.67%, which falls into the very practical category, while the average score for students was 82%, which falls into the practical category. This is due to elements in the video that are designed to facilitate understanding, such as the selection of font type and size, display design, suitability of material presentation, and the use of clear and easily understandable language.

The effectiveness of multilevel representation-based video learning media can be seen from a comparison of pretest and posttest results. The effectiveness of multilevel representation-based video learning media was also supported by an N-Gain value of 0.56, which was in the moderate category, meaning that this media was effective in improving students' abilities. In addition, the effect size value of 4.94, which is in the very strong effect category, shows that the difference between the pretest and posttest results is due to the effective application of multilevel representation-based video learning media. This improvement indicates that students were able to reorganize and reconstruct their conceptual frameworks after engaging with the integrated representations.

The development process was in line with research conducted by Putri et al. (2025), who developed a digital platform-based animated video media on the material of atomic theory development. The research confirms that the design stage, which began with the preparation of storyboards and the design of the material presentation flow, has a significant role in ensuring the clarity of concept representation, visual and audio integration, and ease of media navigation. In this context, the development of multilevel representation-based instructional videos in this study was designed to incorporate macroscopic, sub-microscopic, and symbolic representations in an integrated manner, thereby supporting students' conceptual understanding of complex chemistry material.

The advantage of this layered representational instructional video is that it presents material using a layered representational approach, which includes macroscopic, sub-microscopic, and symbolic representations simultaneously, thereby deepening students' understanding of complex chemistry concepts. Research by Erlina et al. (2023) shows that videos that present concepts visually, symbolically, and narratively can overcome students' difficulties in understanding abstract chemistry concepts, which often lead to misconceptions. Through the use of visual representations and animations, these videos allow students to imagine phenomena at a microscopic level that are difficult to see directly, thereby improving their understanding. This finding supports Johnstone's assertion that misconceptions in chemistry often arise when one representational level dominates instruction without adequate linkage to the others (Petillion & McNeil, 2020).

There are limitations to this study, particularly the relatively small sample size, and this may limit the generalization of the results. In addition, the implementation was limited to one school context, so the results may not fully represent diverse learning environments. Furthermore, the effectiveness analysis focused primarily on short-term learning outcomes and did not examine long-term retention of concepts.

4. CONCLUSION

Based on the results of the development research conducted, the product produced is a multilevel representation-based learning video on atomic model development material that is declared to be highly valid and suitable for use based on expert validation results. The learning video, which integrates macroscopic, sub-microscopic, and symbolic representations, is designed to help students understand abstract chemistry concepts. The implementation results show that the developed media are practical and easy to use in learning. The effectiveness test results show an increase in students' conceptual understanding with a moderate N-gain value and an effect size that indicates a significant impact. These findings provide theoretical implications in the form of support for the multilevel representation theory, which emphasizes the importance of integrating various levels of representation in chemistry learning. Practically, these learning videos may be utilized by chemistry teachers as a learning support medium to enhance student engagement and understanding of atomic model material. This study also recommends the development and application of multilevel representation learning videos in other chemistry materials that have a high level of abstraction, as well as testing on a broader scale and in a wider learning context.

5. ACKNOWLEDGEMENTS

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6. REFERENCES

Adawiyah, R., Laksmiwati, D., Supriadi, S., & Mutiah, M. (2021). Pengembangan E-Modul Berbasis Tiga Level Representasi Pada Materi Kesetimbangan Kimia untuk Siswa Sekolah Menengah Atas Kelas XI. *Chemistry Education Practice*, *4*(3), 262–268. https://doi.org/10.29303/cep.v4i3.2744

Akay, I. N., Rasmawan, R., Ulfah, M., Enawaty, E., & Erlina, E. (2022). Pengembangan Video Pembelajaran Berbasis Multirepresentasi pada Materi Ikatan Kovalen di SMA Negeri 3 Pontianak. *Edukatif : Jurnal Ilmu Pendidikan*, *4*(2), 2454–2475. https://doi.org/10.31004/edukatif.v4i2.2048

Banu, M. E., Tinenti, Y. R., & Tukan, M. B. (2022). Pengaruh Respon Siswa Tentang Penerapan Pendekatan Contextual Teaching And Learning Yang Mengintegrasikan Media Video Pembelajaran Sub Materi Sifat Koloid Terhadap Hasil Belajar Siswa. *Educativo: Jurnal Pendidikan*, *1*(2), 423–429. https://doi.org/10.56248/educativo.v1i2.43

Erlina, E., Enawaty, E., Melati, H. A., & Lestari, I. (2023). Video with multiple representations approach to promote students' conceptual understanding of intermolecular forces. *International Journal of*

Evaluation and Research in Education , *12*(4), 1994–2002. https://doi.org/10.11591/ijere.v12i4.25243

Fitriani, F., Erlina, E., Melati, H. A., Muharini, R., & Lestari, I. (2023). Pengembangan Video Ikatan Kimia Dengan Pendekatan Multipel Representasi Untuk Mengatasi Miskonsepsi. *Edukatif : Jurnal Ilmu Pendidikan*, *5*(1), 86–95. https://doi.org/10.31004/edukatif.v5i1.3476

Irsalina, A. (2018). Analisis Kepraktisan Pengembangan Lembar Kegiatan Peserta Didik (LKPD) Berorientasi Blended Learning Pada Materi Asam Basa. *JKPK (Jurnal Kimia Dan Pendidikan Kimia), 3*(3), 171–182. Https://Doi.Org/ 10.20961/Jkpk.V3i3.25648

Junaidin, J. (2022). Mengidentifikasi Kebutuhan Dalam Pembelajaran Pendidikan Agama Islam Materi Sholat Di Sdn 3 Maria Tahun Pelajara 2022/2023. *Fitrah: Jurnal Studi Pendidikan*, *13*(2), 107–115. https://doi.org/10.47625/fitrah.v13i2.394

Kapici, H. O. (2023). From Symbolic Representation to Submicroscopic One: Preservice Science Teachers' Struggle with Chemical Representation Levels in Chemistry. *International Journal of Research in Education and Science*, *9*(1), 134–147. https://doi.org/10.46328/ijres.3122

Komara, S., Widhiyanti, T., Wiji, & Mu'minah, Q. (2024). Pengembangan Video Pembelajaran Berbasis Intertekstual pada Konsep Materi Reaksi Netralisasi. *Jurnal Riset Dan Praktik Pendidikan Kimia*, *12*(2), 175–185. Https://Doi.Org/10.1234/Jrppk.2024.0175

Lubis, A. N. I., Rohiat, S., & Ginting, M. S. (2022). Pengembangan Media Pembelajaran Kimia Berbasis Guided Discovery Pada Materi Larutan Penyangga. *Alotrop*, *6*(2), 123–130. Https://Doi.Org/10.33369/Alo.V6i2.24423

Mulyanti, S., Nugroho, D. E., & Harahap, L. K. (2023). Student's Chemical Bonds Concept: Rasch Model Analysis. *IJCER (International Journal of Chemistry Education Research)*, *7*(April), 33–38. https://doi.org/10.20885/ijcer.vol7.iss1.art6

Dewi, N. C., & Putrawansyah, F. (2021). Pelatihan Editor Untuk Media Pembelajaran Menggunakan Aplikasi Adobe Premier Pro. *Ngabdimas*, *4*(02), 51–55. Https://Doi.Org/10.36050/Ngabdimas.V4i02.386

Nkomo, S., & Bly, A. (2024). Developing a Threshold Concept Assessment Rubric: Using the Johnstone's Triangle Framework for Understanding Intermolecular Forces. *Journal of Chemical Education*, *101*(11), 4694–4703. https://doi.org/10.1021/acs.jchemed.4c00236

Nurramadhani, A. Z., Sari, R. P., Olii, N. Y. P., Masruhim, M. A., & Rahmadani, A. (2025). Development Of Interactive Flipbook Learning Media On Chemical Bonding Material. *Research And Development In Education (Raden)*, 5(1), 289–305.. Https://Doi.Org/10.22219/Raden.V5i1.39757olii

Nurfitriana, A., Enawaty, E., Harun, A. I., Sahputra, R., & Ulfah, M. (2022). Pengembangan Media Video Animasi pada Materi Perkembangan Model Atom. *Edukatif : Jurnal Ilmu Pendidikan*, *4*(2), 2434–2453. https://doi.org/10.31004/edukatif.v4i2.2032

Olii, N. Y. P., Choirul, M., Tasya, I., Lestari, S., & Rahmadani, A. (2024). Student Experiences And Effectiveness Of Project-Based Learning In An Organic Practicum Chalcone Synthesis Experiments. *Research And Development In Education (Raden)*, *4*(2), 1408–1417. Https://Doi.Org/10.22219/Raden.V4i2.36737

Paristiowati, M., Syaadah, R. S., & Astuti, N. S. (2024).Pengembangan Video Youtube Dan Google Sites Sebagai Media Pembelajaran. *Jurnal Riset Pendidikan Kimia 14*(2), 87–96. Https://Doi.Org/10.21009/JRPK.142.02

Petillion, R. J., & McNeil, W. S. (2020). Johnstone's Triangle as a Pedagogical Framework for Flipped-Class Instructional Videos in Introductory Chemistry. *Journal of Chemical Education*, *97*(6), 1536–1542. https://doi.org/10.1021/acs.jchemed.9b01105

Putri, R. A., Rahayu, R., Nurlaili, N., Lestari, S., & Rahmadani, A. (2025). Development Of Google Sites-Based E-Learning Animation Video For Learning Atomic Theory. *Journal Of Educational Sciences*, 9(6), 5426–5442. Https://Doi.Org/10.31258/Jes.9.6.P.5426-5442

Putri, S. W., Taufik, L., & Qurniati, D. (2022). Spin Jurnal Kimia & Pendidikan Kimia Pengembangan Media Pembelajaran Kimia Berbasis Video Animasi Untuk Meningkatkan Motivasi Belajar Siswa Sman 1 Wanasaba Development of Chemical Learning Media Based on Video Animations To Increase Learning Motivation of. *Spin*, *4*(1), 58–66. https://doi.org/10.20414/spin.v4i1.5092

Ramadana, A. (2023). Development of Interactive Learning Video at Grade X Senior High School. *Journal of Educational Chemistry (JEC)*, *4*(2), 133–144. https://doi.org/10.21580/jec.2022.4.2.12347

Sundari,R., Suandi, S., Fatah, H. F. (2021). Penggunaan Media Video Berbantuan LKPD Untuk Meningkatkan Hasil Belajar Siswa Materi Kesetimbangan Kimia Kelas XI MIPA Di SMA Negeri 2 Palangka Raya. *Jurnal Ilmiah Kanderang Tingang*, *12*(2), 121–137. Https://Doi.Org/10.37304/Jikt.V12i1.127

Richey, R. C., & Klein, J. D. (2009). *Design And Development Research: Methods, Strategies, And Issues*. Routledge.

Sanchez, J. M. P. (2025). Multiple representations framework in technology acceptance: A structural equation modeling of science educational videos in teaching and learning redox reactions. *STEM Education*, *5*(5), 855–881. https://doi.org/10.3934/steme.2025038

Santoso, R. L., Kamaludin, A., & Safarova, A. (2023). Development of an Animated Video on Atomic Structure Material Integrated with Qur'an for Online Learning Using PowToon Web Apps. *Journal of Natural Science and Integration P-ISSN*, *6*(2), 239–256. https://doi.org/10.24014/jnsi.v6i2.22216

Spitha, N., Zhang, Y., Pazicni, S., Fullington, S. A., Morais, C., Rae Buchberger, A., & Doolittle, P. S. (2023). Supporting submicroscopic reasoning in students' explanations of absorption phenomena using a simulation-based activity. *Chemistry Education Research and Practice*, *25*(1), 133–150. https://doi.org/10.1039/d3rp00153a

Tukan, V. D. L., Tinenti, Y. R., & Lawung, Y. D. (2022). Pengaruh Respon Tentang Media Video Pembelajaran Terhadap Hasil Belajar Materi Larutan Elektrolit Non Elektrolit SMA Gelekat Lewo Boru Kecamatan Wulanggitang Kabupaten Flores Timur Tahun 2020/2021. *Wahana*, *74*(1), 86–94. https://doi.org/10.36456/wahana.v74i1.4197

Widarti, H. R., Rokhim, D. A., & Syafruddin, A. B. (2020). The development of electrolysis cell teaching material based on stem-pjbl approach assisted by learning video: A need analysis. *Jurnal Pendidikan IPA Indonesia*, *9*(3), 309–318. https://doi.org/10.15294/jpii.v9i3.25199

Wijaya, W. U. (2020). Analisis Kebutuhan Untuk Mengembangkan Media Video. *JTC-RE: Journal of Tropical Chemistry Research and Education*, *2*(1), 59–67.

Zakyanto, M. D., & Wintarti, A. (2022). Pengembangan Game Edukasi Berbasis Android Sebagai Suplemen Pembelajaran Pada Materi Perbandingan. *MATHEdunesa*, *11*(1), 1–11. https://doi.org/10.26740/mathedunesa.v11n1.p1-11

Zeinstra, L., Kupers, E., Loopers, J., & de Boer, A. (2023). Real-time teacher-student interactions: The dynamic interplay between need supportive teaching and student engagement over the course of one school year. *Teaching and Teacher Education*, *121*, 103906. https://doi.org/10.1016/j.tate.2022.103906